

## 1.0 INTRODUCTION

This report presents the Feasibility Study (FS) for the Portland Harbor Superfund Site in Portland, Oregon (**Figure 1-1**). Portland Harbor was evaluated and proposed for inclusion on the National Priorities List (NPL) pursuant to Section 105 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA, or Superfund), 42 U.S.C. §9605, by the U.S. Environmental Protection Agency (EPA) and formally listed as a Superfund Site in December 2000. The lead agency for this site is EPA.

The basis of this FS is environmental data collected and compiled by the Lower Willamette Group (LWG) and other parties since the inception of the Portland Harbor Remedial Investigation and Feasibility Study (RI/FS) in 2001<sup>1</sup>. The LWG is performing the remedial investigation (RI) and FS for the Portland Harbor Superfund Site (Site) pursuant to an EPA Administrative Settlement Agreement and Order on Consent for Remedial Investigation/Feasibility Study (AOC; EPA 2001, 2003, 2006). Oversight of LWG's Portland Harbor RI and FS is being provided by EPA with support from Oregon Department of Environmental Quality (DEQ).

The RI (insert citation) has been completed and has characterized the Site sufficiently to define the nature and extent of the source material and the Site-related contaminants based on data collected through July of 2010.. Baseline ecological and human health risk assessments (Windward 2013; Kennedy Jenks 2013) have also been completed. The site characterization and baseline risk assessments are sufficient to complete the FS for the Site.<sup>2</sup>

This FS focuses on approximately ten miles of the lower Willamette River from RM 1.9 (at the upriver end of the Port of Portland's Terminal 5) to RM 11.8 (near the Broadway Bridge), sometimes referred to as the "site" in this FS for convenience. The terms site, harbor-wide, and site-wide used in this FS generally refer to the sediments, pore water, and surface water within this reach of the lower Willamette River, not to the upland portions (above elevation 13.3 feet North American Vertical Datum of 1988 [NAVD88]) of the Portland Harbor Superfund Site.

<sup>1</sup> Upland source control efforts, including site-specific upland source control studies and implementation of source control measures, are performed under the oversight of the Oregon Department of Environmental Quality and are not within the scope of the Agreement and Order on Consent and Statement of Work for the in-water portion of the Site.

<sup>2</sup> Although this section identifies many specific sources of contamination, neither this section nor this report generally is intended as an exhaustive list of current or historical sources of contamination.

This FS is consistent with CERCLA, as amended (42 United States Code [U.S.C.] 9601 et seq.), and its regulations, the National Oil and Hazardous Substances Pollution Contingency Plan (40 Code of Federal Regulations [CFR] Part 300), commonly referred to as the National Contingency Plan (NCP) and was prepared in accordance with EPA guidance. Guidance documents used in preparing this FS include:

- *Interim Final Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA 1988)
- *Clarification of the Role of Applicable or Relevant and Appropriate Requirements in Establishing Preliminary Remediation Goals under CERCLA* (EPA 1997a)
- *Rules of Thumb for Superfund Remedy Selection* (EPA 1997b)
- *Principles for Managing Contaminated Sediment Risks at Hazardous Waste Sites* (EPA 2002)
- *Contaminated Sediment Remediation Guidance for Hazardous Waste Sites* (EPA 2005)
- *Technical Resource Document on Monitored Natural Recovery* (EPA 2014)

## 1.1 PURPOSE AND ORGANIZATION OF REPORT

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The purpose of the FS is to identify, develop, screen, and evaluate a range of remedial alternatives to reduce risks from contaminated media to acceptable levels and to provide the regulatory agencies with sufficient information to select a remedy that meets the requirements established in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). This FS report is comprised of four sections as described below.

- Section 1 – Introduction: Provides a summary of the Site RI, including Site description, Site history, nature and extent of contamination, contaminant fate and transport, and baseline human health and ecological risks.
- Section 2 - Identification and Screening of Technologies: Develops remedial action objectives (RAOs), develops preliminary remediation goals (PRGs) for addressing human health and ecological risks posed by contaminants in sediment and tissue, develops general response actions (GRAs) for each medium of interest, identifies areas of media to which general response actions might be

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applied, identifies and screens remedial technologies and process options, and identifies and evaluates technology process options to select a representative process for each technology type retained for consideration.

- Section 3 - Development and Screening of Alternatives: Presents a range of remedial alternatives developed by combining the feasible technologies and process options. The alternatives are then refined and screened to reduce the number of alternatives that will be analyzed in detail. This screening aids in streamlining the feasibility study process while ensuring that the most promising alternatives are being considered.
- Section 4 - Detailed Analysis of Alternatives: Provides the detailed analysis of each alternative with respect to the following seven criteria: 1) overall protection of human health and the environment, 2) compliance with ARARs, 3) long-term effectiveness and permanence, 4) reduction of toxicity, mobility, or volume through treatment, 5) short-term effectiveness, 6) implementability, and 7) cost. In addition to the detailed analysis, a comparative analysis of remedial action alternatives is also presented in this section. EPA also recognizes that this site affects many stakeholders along the river and the evaluation of remedial alternatives considers impacts to these communities.

## 1.2 BACKGROUND INFORMATION

### 1.2.1 Site Description

The Willamette River originates within Oregon in the Cascade Mountain Range and flows approximately 187 miles north to its confluence with the Columbia River, and is one of 14 American Heritage Rivers in the country. It is the 19th largest river in the United States, and drains 11.7 percent of the State of Oregon. As Oregon's major port and population center, the lower Willamette River sees a great variety of uses including shipping, industrial, fishing, recreational, natural resource, and other uses. The lower reach of the Willamette River from River Mile (RM) 0 to approximately RM 26.5 is a wide, shallow, slow moving segment that is tidally influenced with tidal reversals occurring during low flow periods as far upstream as RM 15. The river segment between RM 3 and RM 10 is the primary depositional area of the lower Willamette River system. The lower reach has been extensively dredged to maintain a 40-foot deep navigation channel from RM 0 to RM 11.7.

The Portland Harbor RI/FS Study Area is located along the lower reach of the lower Willamette River in Portland, Oregon known as Portland Harbor (**Figure 1-1**). The RI/FS Study Area extends from river mile (RM) 1.9 to 11.8 and up to a vertical elevation of 13.3 feet NAVD88. While the harbor area is extensively industrialized, it

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occurs within a region characterized by commercial, residential, recreational, and agricultural uses. Land use along the lower Willamette River in the harbor includes marine terminals, manufacturing, and other commercial operations, as well as public facilities, parks, and open spaces. **Figures 1.2-1a through 1.2-1d** illustrate land use zoning within the lower Willamette River as well as waterfront land ownership. The State of Oregon owns certain submerged and submersible lands underlying navigable and tidally influenced waters. The ownership of submerged and submersible lands is complicated and has changed over time (**Figure 1.2-2**).

Today, the Willamette River is noticeably different from the river prior to industrial development that commenced in the mid to late 18<sup>th</sup> century. Historically, the Willamette was wider, had more sand bars and shoals, and fluctuated greatly in volume. In contrast, the main river now has been redirected and channelized, several lakes and wetlands in the lower floodplain have been filled and agricultural lands converted to urban or industrial areas. The end result is a river that is deeper and narrower than it was historically with higher banks that prevent the river from expanding during high-flow events. The Willamette River channel, from the Broadway Bridge (RM 11.6) to the mouth (RM 0), currently varies in width from 600 to 1,900 feet. Further, the installation of a series of dams moderate fluctuations of flow in the lower Willamette River.

Little, if any, original shoreline or river bottom exists that has not been modified by the above actions, or as a result of them. Much of the shoreline has been raised, filled, stabilized, and/or engineered and contains overwater piers and berths, port terminals and slips, stormwater and industrial wastewater outfalls and combined sewer overflows (CSOs), and other engineered features. Constructed structures, such as wharfs, piers, floating docks, and pilings, are especially common in Portland Harbor where urbanization and industrialization are most prevalent. These structures are built largely to accommodate or support shipping traffic within the river and to stabilize the riverbanks for urban development. Constructed structures are clearly visible in the aerial photos provided in **Figures 1.2-3a through 1.2-3n**

Armoring to stabilize banks covers approximately half of the harbor shoreline, which is integral to the operation of activities that characterize Portland Harbor. Riprap is the most common bank-stabilization measure. However, upland bulkheads and rubble piles are also used to stabilize the banks. Some riverbank areas and adjacent parcels have been abandoned and allowed to revegetate, and beaches have formed along some modified shorelines due to relatively natural processes.

A federal navigation channel, maintained to a depth of -40 feet with an authorized depth of -43 feet, extends from the confluence of the lower Willamette River with the Columbia River to RM 11.7 (**Figure 1.2-4**). The lower Willamette River federal

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navigation project was first authorized in 1878 to deepen and maintain parts of the Columbia River and lower Willamette River with a 20-foot minimum depth. The depth of the navigation channel has been deepened at various intervals since that time (i.e., increased to 25 feet in 1899, 30 feet in 1912, 35 feet in 1930, and 40 feet in 1962). Container and other commercial vessels regularly transit the river. Certain parts of the river require periodic maintenance dredging to keep the navigation channel at its maintained depth. In addition, the Port of Portland and other private entities periodically perform maintenance dredging to support access to dock and wharf facilities. Dredging activity has greatly altered the physical and ecological environment of the river in Portland Harbor.

Development of the river has resulted in major modifications to the ecological function of the lower Willamette River. However, a number of species of invertebrates, fishes, birds, amphibians, and mammals, including some protected by the Endangered Species Act (ESA), use habitats that occur within and along the river. The river is also an important rearing site and pathway for migration of anadromous fishes, such as salmon and lamprey. Various recreational fisheries, including salmon, bass, sturgeon, crayfish, and others, are active within the lower Willamette River. A detailed description of ecological communities in Portland Harbor is presented in the Baseline Ecological Risk Assessment (BERA) provided as Appendix G of the RI Report.

### 1.2.2 Site History

Since the late 1800s, the Portland Harbor section of the Lower Willamette River has been extensively modified to accommodate a vigorous shipping industry. Modifications include redirection and channelization of the main river, draining seasonal and permanent wetlands in the lower floodplain, and relatively frequent dredging to maintain the navigation channel. Historically, the Willamette was wider, had more sand bars and shoals, and fluctuated greatly in volume.

The lower Willamette River and its adjacent upland areas have been used for industrial, commercial, and shipping operations for over a century. Commercial and industrial development in Portland Harbor accelerated in the 1920s and again during World War II, which reinvigorated industry following the Great Depression. Before World War II, industrial development primarily included sawmills, manufactured gas production (MGP), bulk fuel terminals, and smaller industrial facilities. During World War II, a considerable number of ships were built at military shipyards located in Portland Harbor. Additional industrial operations located along the river in the post-World War II years included wood-treatment, agricultural chemical production, battery processing, ship loading and unloading, ship maintenance, repair and dismantling, chemical manufacturing and distribution, metal recycling, steel mills, smelters, foundries, electrical production, marine shipping and associated operations, rail yards, and rail car

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manufacturing. Many of these operations continue today. Contaminants associated with these operations were released from various sources and migrated to the lower Willamette River. The long history of industrial and shipping activities in the Portland Harbor, as well as agricultural, industrial, and municipal activities upstream of Portland Harbor, has contributed to chemical contamination of surface water and sediments in the lower Willamette River.

#### 1.2.2.1 Investigation History

Many environmental investigations by private, state, and federal agencies have been conducted, both in the lower Willamette River and on adjacent upland properties, to characterize the nature and extent of contamination in the river, as well as to identify potential sources of contaminants that could continue to enter the river. Investigations have been conducted in Portland Harbor from the 1920s to the present, with most studies being performed from the late 1970s through the present. Nearly 700 documents and data sets were obtained that address conditions in the lower Willamette River. Specific historical and recent studies and data sets were selected for inclusion in the data set used to characterize and evaluate the Study Area in the RI and FS reports.

Site data were collected by the LWG during four major rounds of field investigations between 2001 and 2010 to complete the RI. The investigations were often timed around varying river stages, river flows, and storm events. The field investigations first began in 2001 in the Initial Study Area (ISA) as defined by the AOC, SOW, and Programmatic Work Plan as RM 3 to RM 9. As the studies commenced, the Study Area was expanded from RM 1.9 to RM 11.8, as well as a portion of Multnomah Channel. Studies conducted by the LWG also included areas downriver of the Study Area to the confluence with the Columbia River at RM 0 and upriver to RM 28.4. Surface and subsurface sediment samples, sediment trap samples, riverbank sediment and soil samples, surface water samples, stormwater and stormwater solids samples, groundwater samples, transition zone water (TZW) samples, and biota/tissue samples were collected and analyzed during the various investigations conducted. Additional studies were conducted by specific parties at several sites within the Study Area with EPA oversight including offshore areas of: Arkema, Gasco, Siltronic, Terminal 4, and River Mile 11 East. Some of the data generated from these investigations were included in the RI data set and additional later data from these same sites was included in the FS data set (see Section 1.3).

#### 1.2.2.2 Upland Source Control Measures

Identifying current sources of contamination to the Study Area and eliminating or minimizing these pathways where possible is critical for remedy effectiveness as well as evaluating the recontamination potential of a cleanup. In February 2001, DEQ, EPA,

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and other governmental parties signed a Memorandum of Understanding (MOU) agreeing that DEQ, using state cleanup authority, has lead technical and legal responsibility for identifying and controlling upland sources of contamination that may impact the river (e.g., sediment, groundwater, transition zone water, and/or surface water). Currently, DEQ is investigating or directing source control work at over 90 upland sites in Portland Harbor and evaluating investigation and remediation information at more than 80 other upland sites in the vicinity (ODEQ 2103a). Additionally, DEQ is working with the City of Portland under an Intergovernmental Agreement to identify and control upland sources draining to the Study Area through 39 city outfalls, and with the Oregon Department of Transportation on controlling sources in highway and bridge runoff drained to the Study Area (City of Portland 2012).

The City prepared a CSO Management Plan (City of Portland, 2005) with recommendations to address wet weather overflow discharges, including implementation of storage and treatment facilities along the Willamette River (“Big Pipe project”) to control the CSO discharges. The primary means for increasing the storage capacity was through construction of the West Side Tunnel (completed in 2006) and the East Side Tunnel (completed in 2011).

The cleanup of known or potentially contaminated upland sites is tracked in DEQ’s Environmental Cleanup Site Information (ECSI) database, which is available online at <http://www.deq.state.or.us/lq/ECSI/ecsi.htm>, and source control efforts are summarized in DEQ’s Portland Harbor Upland Source Control Milestone and Summary Report (<http://www.deq.state.or.us/lq/cu/nwr/PortlandHarbor/jointsource.htm>).

**Figures 1.2-6a through 1.2-6e** graphically display the status of DEQ source control evaluations as of 2014 for various sites along the Study Area by potential release/migration pathways to the river.

Sources are discussed in more detail in subsections 1.2.3.3 and 1.2.3.4. An important overall assumption of the FS is that upland sources in Portland Harbor will be controlled sufficient to achieve project goals through the DEQ process. Although sources are discussed in the FS, the sediment remedy is not intended to address or control upland sources. Groundwater is summarized in the subsections below because groundwater may impact decisions about sediment caps within the Site. Bank conditions are summarized because EPA may include some bank areas within the Portland Harbor Site based on future site-specific determinations.

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### 1.2.2.3 Early Action Sites

Within Portland Harbor, separate orders have been executed by EPA with various parties for five specific sites. These sites are:

1. Terminal 4 – conducted by the Port of Portland
2. Gasco – conducted by NW Natural
3. Gasco and Siltronic – conducted by NW Natural and Siltronic
4. Arkema – conducted by Arkema
5. RM 11 E – conducted by Glacier Northwest, Inc., Cargill, Inc., PacifiCorp, CBS Corporation, DIL Trust, and City of Portland.

These projects are currently in various stages of completion as described below. Some information from some of these early action sites has been included in the Portland Harbor FS database (as detailed in Section 1.3) for use in the development and detailed evaluation of alternatives.

- **Terminal 4** – The Port of Portland has been implementing a removal action at Terminal 4. A Phase I Abatement Measure was completed in 2008 that consisted of remediation and maintenance dredging of approximately 13,000 cubic yards of sediment. Remediation consisted of dredging 6,315 cubic yards of contaminated sediment and placing it in an off-site disposal facility, isolating contaminated sediment in the back of Slip 3 with a cap made of organoclay-sand mix, and stabilizing the bank along Wheeler Bay.
- **Gasco** – A removal action was conducted at the Gasco site between August and October 2005. Approximately 15,300 cubic yards of a tar-like material and tar-like contaminated sediment were removed by dredging from the riverbank and nearshore area adjacent to the Gasco facility and disposed of off-site. After the removal action, an organoclay mat was placed along an upper-elevation band of the shoreline dredge cut. This mat was secured with placement of an overlying sand cap and quarry spalls. A 1 foot thick sand cap and 0.5 foot of erosion protection gravel was placed over the remainder of the removal area (0.4 acres). Approximately 0.5 foot of a “fringe cap” of sand material was placed over 2.3 acres of the area surrounding the removal area.
- **Gasco and Siltronic** – NW Natural and Siltronic are conducting site characterization and design evaluations for the area adjacent to their two facilities. Under the order, NW Natural and Siltronic have agreed to perform

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further characterization, studies, analysis and preliminary design that will lead ultimately to a final remedy at the GASCO Sediments Site. Conducting this work will facilitate construction of the final remedy to begin expeditiously following issuance of a Record of Decision (ROD) for the Portland Harbor Superfund Site. The remedial action for the NW Natural and Siltronic sediments will be implemented in coordination with and following completion of any necessary upland NW Natural and Siltronic source control work being managed by DEQ.

- **Arkema** – Under an AOC with EPA, Arkema conducted additional site characterization and preliminary design evaluations for a planned Removal Action.
- **River Mile 11 East** - A group of Respondents, collectively known as the RM11E Group (includes Glacier Northwest, Inc., Cargill, Inc., PacifiCorp, CBS Corporation, DIL Trust, and City of Portland), entered into an AOC to perform supplemental RI/FS work in support of preliminary design activities.

In addition, a near-shore sediment removal adjacent to the BP Arco Bulk Terminal in 2007-08 under DEQ oversight resulted in 12,300 cubic yards of petroleum-contaminated soil and sediment being removed and disposed of off-site, and replaced with clean fill in conjunction with the installation of a new steel sheet-pile seawall along the riverbank of the BP Arco Bulk Terminal property.

### 1.2.3 Nature and Extent of Contamination

Due to the large number of contaminants detected at the Study Area in various media, the nature and extent of contamination focuses on specific contaminants or groups of contaminants selected by evaluating several criteria discussed in Section 5.1 of the RI.

Fourteen indicator contaminants were discussed in detail in Section 5 of the RI report based on frequency of detection, ease of cross media comparisons, co-location with other contaminants, widespread sources, and similar chemical structures and properties. Information regarding the remaining contaminants is provided in Appendix D of the RI. The nature and extent of indicator contaminants in sediment and surface water are summarized in the following sections. As discussed in Section 5.1 of the RI, additional contaminants beyond the indicator contaminants presented in the RI (and summarized in this section) are present at the site at concentrations that may pose unacceptable risk to human health and the environment. Section 2.2.1 of the FS identifies the contaminants of concern (COCs) selected for the Portland Harbor Superfund Site and discusses the process for selecting the COCs. Groundwater is summarized in the subsections below because groundwater may impact decisions about sediment caps

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within the Site. Bank conditions are summarized because EPA may include some bank areas above elevation 13.3 feet North American Vertical Datum of 1988 [NAVD88] within the Portland Harbor Site based on future site-specific determinations.

### 1.2.3.1 Sources

Historical and current locations of various industrial facilities identified along the lower Willamette River are provided by industrial sector in **Figures 1.2-5a** through **1.2-5j**. The approximate location of facilities is shown on the maps; however, the actual extent of historical and current facilities/operations is not shown. Detailed information regarding historic and current sources of contamination in the lower Willamette River is provided in Section 4 of the RI Report.

Each of these industrial sectors has been typically associated with the use of various chemicals. The contaminants are dependent upon the activities conducted, but the contaminants most commonly associated with each industry sector include the following:

Industrial Sector	Common Industry Contaminants
Ship Building, Dismantling, and Repair	Volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), total petroleum hydrocarbons (TPH), metals (e.g., Cu, Cr, Pb, Hg, Zn), phthalates, butyltins
Wood Products and Wood Treating	VOCs, SVOCs, TPH, benzene, PAHs, metals (e.g., As, Cr, Cu, Zn), pesticides, fungicides, biocides, borates, pentachlorophenol, creosote, acid/alkaline wastes, dioxins
Chemical Manufacturing and Distribution	Vary depending on the operations, but chemical manufacturing known to have occurred within Portland Harbor includes pesticides, herbicides, VOCs, SVOCs, dioxins/furans, metals, PCBs, solvents, acid/alkaline wastes, benzene, TPH, and PAHs
Metal Recycling, Production, and Fabrication	PCBs, PAHs, heavy metals, asbestos, cyanide, phthalates, fuel additives(ethylene glycoland products of incomplete combustion, battery acid, oil and grease, lubricants, paint pigments or additives, ionizing radioactive isotopes, transmission and brake fluids, antifreeze, benzene, chemical residue, heating oil, petroleum products, solvents, hydraulic fluids, oils, fuels, grease, other lubricants, chemical additives

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Industrial Sector	Common Industry Contaminants
Manufactured Gas Production	VOCs including benzene, toluene, ethylbenzene, and xylenes (BTEX), SVOCs, PAHs, TPH, metals, and cyanide
Electrical Production and Distribution	PCBs, TPH, and PAHs
Bulk Fuel Distribution and Storage, and Asphalt Manufacturing	VOCs (benzene), SVOCs, PAHs, TPH, metals, gasoline additives (methyl tert-butyl ether [MTBE], ethylene dibromide [EDB], ethylene dichloride [EDC])
Steel Mills, Smelters, and Foundries	Metals, TPH, PAHs, PCBs, fuel additives, chlorinated solvents
Commodities Maritime Shipping and Associated Marine Operations	Spillage of raw materials during transport to and from vessels, butyltins, metals, TPH, fuel additives, chlorinated solvents
Rail Yards	VOCs, SVOCs, TPH, PCBs, and heavy metals

Contaminants released during industry operations and/or other activities to the air, soil, groundwater, surface water, and/or impervious surfaces can potentially migrate to the lower Willamette River via the following pathways: direct discharge, overland transport, groundwater, riverbank erosion, atmospheric deposition, overwater activities, and upstream watershed.

One key migration pathway for contaminants from these various industries to migrate to the river was through direct discharge via numerous public and private outfalls, including storm drains and combined sewer overflows, which were and some still are located along both shores of the lower Willamette River in the metropolitan area. In the early 1900s, rivers in the United States were generally used as open sewers, which was also true for the Willamette (Carter 2006). The process water from a variety of industries, including slaughterhouses, chemical plants, electroplaters, paper mills, and food processors, was discharged directly into the river. In the 1950s, municipal conveyance systems included interceptors and associated facilities were installed to reduce the volume of untreated sewage discharging to the Willamette from the City of Portland and regulatory actions in the 1960s and 1970s, such as the Clean Water Act, gradually reduced the direct discharge of waste to the Willamette River.

Historical releases from upland or overwater activities within the Study Area likely contributed to the majority of the observed contaminant distribution in sediments within the Study Area. The majority of current contaminant pathways to the river (soil

erosion, groundwater, and stormwater) from upland sources are a result of historical operational practices, spills, and other releases.

In addition, point and nonpoint discharges within the Willamette River Basin are potential sources of contamination in sediment, surface water, and biota in the Study Area. Contaminants in discharges and runoff from diverse land uses in the basin eventually enter the river upstream of the Study Area. Contaminant loading from sediment transport and water from upstream areas throughout the last century also contributed to the conditions currently observed in the Study Area.

#### 1.2.3.2 Sediment

Sediment samples were collected from the Study Area for consideration in the FS. Much of the sampling was conducted by the LWG under the terms of AOC and consistent with EPA approved work plans. Sample locations were biased toward areas of known or suspected contamination based on existing information. Additional sampling was conducted both upstream and downstream of the Study Area. Summary statistics of surface and subsurface sediment results for the contaminants presented above are provided in **Table 1.2-1**. Generally, concentrations of the indicator contaminants were greater in subsurface sediment samples relative to surface samples, confirming that historical inputs were greater than current inputs. However, as discussed below, there are noted areas within the Study Area where surface concentrations are greater than subsurface concentrations likely reflecting more recent releases and/or disturbances of bedded sediments.

#### PCBs

With few exceptions, the highest PCB concentrations in surface sediment are present in nearshore areas outside the navigation channel and proximal to currently known or suspected sources (**Figure 1.2-5a**). Similar spatial and concentration trends are observed for subsurface sediments (**Figure 1.2-5b**). Total PCB concentrations are typically greater in the subsurface than in surface sediments, indicating PCB sources are primarily historical. Overall, surface sediment PCB concentrations in the Study Area are greater than those in the upriver (upstream of Ross Island) and downstream (mainstem of the lower Willamette River downstream of RM 1.9 and Multnomah Channel) reaches.

### **Dioxins/Furans**

Total PCDD/Fs were detected at several locations along the eastern and western nearshore zones and in Swan Island Lagoon (**Figure 1.2-6a**). Limited surface PCDD/F data are available; thus, spatial resolution is somewhat limited, especially in the navigation channel. Total PCDD/F concentrations in the subsurface are generally greater than that observed in surface sediments (**Figure 1.2-6b**). The higher concentrations typically observed in subsurface sediment relative to concentrations in surface sediment are indicative of a primarily historical input of these contaminants to the Study Area.

### **DDx**

The highest reported DDx concentrations in surface sediments are present in localized areas in the western nearshore zones between RMs 6.3 and 7.5 (**Figure 1.2-7a**). DDx concentrations are typically greater in the subsurface than in the surface layer, indicating DDx sources are primarily historical (**Figure 1.2-7b**). The concentrations of DDx in surface sediments are greater in the Study Area than those in the upriver, downtown, Multnomah Channel, and downstream reaches.

### **Total PAHs**

The highest reported concentrations of total PAH in surface sediments generally occur in the western nearshore zone downstream of RM 6.8, and on the east side at approximately RM 4.5 (**Figure 1.2-8a**). Total PAH concentrations are generally higher in subsurface sediments within the Study Area as a whole, pointing to higher historical inputs to the Study Area (**Figure 1.2-8b**). Within the Study Area, total PAHs in sediment are generally dominated by HPAHs. Surface sediments from the western nearshore zone appeared to exhibit higher proportions of LPAHs than sediments from the eastern nearshore zone and the navigation channel, but follow the general trend of HPAH dominance. Subsurface generally exhibit similar PAH profiles to the surface sediments.

### **Bis(2-ethylhexyl) phthalate**

The highest reported concentrations of bis(2-ethylhexyl) phthalate were observed in samples collected in surface and subsurface sediment from the eastern nearshore in Swan Island Lagoon, between RM 3.8 and 4.1, and in the International Terminals Slip (**Figures 1.2-9a and 1.2-9b**).

### **Total Chlordanes**

The highest reported concentrations of total chlordanes were observed along the western nearshore zone between approximately RM 7 and 9 (**Figure 1.2-10a**). Total chlordane concentrations are generally higher in subsurface sediments within the Site, pointing to higher historical inputs to the Site (**Figure 1.2-10b**).

### **Aldrin and Dieldrin**

Aldrin and dieldrin, have similar chemical structures and are discussed together here because aldrin readily undergoes biotic and abiotic transformation to dieldrin. The highest reported concentrations of aldrin were observed in the western nearshore zone from RM 6.8 to RM 7.4 and from RM 8.6 to 8.8 (**Figures 1.2-11a**). The highest reported surface concentrations of dieldrin were observed in Swan Island Lagoon and in the western nearshore zone from RM 8 to 9 (**Figure 1.2-12a**). Aldrin and dieldrin concentrations are higher in subsurface sediments than surface sediments within the Site (**Figures 1.2-11b and 1.2-12b**), pointing to higher historical inputs to the Study Area.

### **Metals**

The highest reported arsenic concentrations were reported in several locations in the eastern nearshore at RM 2.3, RM 5.6, RM 7.2, near the mouth of Swan Island Lagoon, and in the western nearshore area at RM 6.8, RM 8.6, and RM 10.2 (**Figure 2.1-13a**). Arsenic concentrations are generally greater in the surface sediments than in subsurface sediments within the Study Area (**Figure 1.2-13b**).

The highest reported chromium concentrations were observed in the eastern nearshore zone at RM 2.1-2.4, RM 3.7-4.4, RM 5.6-5.9, and in Swan Island Lagoon, and in the western nearshore zone at RM 6-6.1, RM 6.8-6.9, and RM 8.8-9.2 (**Figure 2.1-14a**). Chromium concentrations are generally greater in the surface sediments than in subsurface sediments within the Study Area (**Figure 1.2-14b**).

The highest surface and subsurface copper concentrations were observed in the eastern nearshore zone at RM 2.1-2.4, RM 3.7-4, RM 5.5-6.1, RM 11.1-11.3, and Swan Island Lagoon, and in the western nearshore zone from RM 4.3 through 10.4 (**Figure 1.2-15a**). Copper concentrations are generally similar in surface and subsurface sediments in the Study Area (**Figure 1.2-15b**).

The highest surface sediment zinc concentrations were found in the eastern nearshore zone at RM 4-4.6, RM 5.6, and RM 6.7, and the western nearshore zone between RM 8 and 9.2 (**Figure 1.2-16a**). The highest subsurface concentrations of zinc were found in the western nearshore zone at RM 9-9.2 and in Swan Island Lagoon (**Figure 1.2-16b**). Zinc concentrations are generally similar in the surface sediments and subsurface sediments within the Study Area.

### **Tributyltin Ion**

The highest concentrations of tributyltin were reported in surface sediment near the eastern nearshore zone at RM 3.7, RM 7.5, and in Swan Island Lagoon (**Figure 1.2-17a**). The highest subsurface concentrations of tributyltin are found in the eastern nearshore zone between RM 7 and RM 8, and in Swan Island Lagoon (**Figure 1.2-17b**).

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Concentrations are generally higher in subsurface sediments than surface sediments within the Site, pointing to primarily historical inputs to the Study Area.

### 1.2.3.3 Surface Water

Concentrations of contaminants in surface water samples varied both spatially and with river flow. Surface water sample locations with the highest reported contaminant concentrations are as follows:

River Mile	River Location	Sample ID	Contaminants
MC	Transect	W027	PCDD/Fs, aldrin, copper
2	East	W001	PCBs, DDx
	West	W002	chlordanes
	Transect	W025	PCBs, BEHP, aldrin
3	International Slip	W004	PCBs
	East	W028	PCBs
4	West	W029	BEHP, chlordanes
5	East	W030	PCBs, DDx, chlordanes
6	East	W013, W014, W032	PCBs, PCDD/Fs
	West	W015, W031	PCBS, PCDD/Fs, DDx, PAHs, chlordanes, aldrin, dieldrin, copper
	Transect	W011	PCDD/Fs, BEHP, aldrin
7	West	W016, W033	PCBs, PCDD/Fs, DDx
8	West	W019, W036	PCBs, PAHs, BEHP
9	West	W022, W037	DDx, zinc
11	Transect	W023	PCDD/Fs, chlordanes, copper
16	Transect	W024	BEHP, copper

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RM 7E, RM 8E, RM 9E, and RM 10 was not sampled.

Concentrations of contaminants in surface water within the Study Area are generally higher than those entering the upstream limit of the Study Area (W024 at RM 16) under all flow conditions. The highest contaminant concentrations in surface water within the Site were found near known sources.

#### 1.2.3.4 Groundwater

**Figure 1.2-18a through Figure 1.2-18h** and **Figure 1.2-19** (inset of the Doane Lake area) show the nature and extent of known contaminated plumes currently or potentially discharging to the river. Cleanup of contaminated groundwater is being managed by DEQ under an MOU with EPA. The following provides a discussion of the groundwater plumes presented in **Figures 1.2-18a through 1.2-18h** and **1.2-19**:

#### East Side of Willamette River

##### **RM 2**

Evrast Oregon Steel Mill –Contaminants detected in groundwater above screening levels are manganese and arsenic. Arsenic concentrations in beach monitoring wells exceed MCLs. Manganese was detected in beach wells at concentrations exceeding aquatic life screening criteria. Further evaluation of groundwater discharge at the Evrast Oregon Steel Mill site is ongoing.

##### **RM 3.5**

Time Oil – Contaminants are pentachlorophenol, arsenic, gasoline- and diesel-range hydrocarbons. A pump and treat system is operating to prevent migration of the pentachlorophenol plume from reaching the river via a stormwater outfall and prevent offsite migration to the Premier Edible Oils property. There are three TPH plumes identified at this site; the northern plume is not discharging to the river, the middle plume is discharging to the river, but arsenic is the only contaminant with concentrations exceeding SLVs. The southern upland plume migrates a short distance onto the Premier Edible Oils property and is not discharging to the river.

Premier Edible Oil – Contaminants are TPH (diesel-range hydrocarbons), manganese, and arsenic.

Schnitzer Steel Industries – A halogenated VOC plume is known to be discharging to the river. Contaminants include cis-1,2-dichloroethene (cis-1,2-DCE), tetrachloroethene (PCE), and trichloroethene (TCE).

##### **RM 4.5**

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Terminal 4 Slip 3 – Contaminants include TPH (diesel-range hydrocarbons). Source control measures to address contaminated groundwater discharges have been completed and monitoring is ongoing. **RM 6**

McCormick & Baxter Creosote Co. – Contaminants include pentachlorophenol, PAHs, arsenic, chromium, copper, and zinc. An upland groundwater barrier wall system and in-river sediment cap has been installed that isolates contaminated groundwater from the river. A 5-Year Review completed in 2011 by EPA and DEQ determined constructed remedies are protective to human health and the environment.

#### **RM 11**

Tarr Oil – A halogenated VOC plume is not known to be releasing to the river. Contaminants include cis-1,2-DCE, PCE, TCE, and vinyl chloride

#### **West Side of Willamette River**

#### **RM 4**

Kinder Morgan Linnton Bulk Terminal – A TPH plume is located onsite and has released to the river. Contaminants include LNAPL, diesel-range hydrocarbons, residual-range hydrocarbons, and gasoline-range hydrocarbons. A sheet-pile wall has been constructed to prevent LNAPL migration to the river.

#### **RM 5**

BP Arco Bulk Terminal – A TPH plume has discharged to the river. Contaminants include TPH (gasoline-range and diesel-range hydrocarbons) and LNAPL, and the plume extends under the adjacent downstream property. A sheet-pile wall with groundwater hydraulic control system is in place. A groundwater pump and treat system and LNAPL recovery system is in use.

Exxon Mobil Bulk Terminal – A TPH plume has discharged to the river. Contaminants include gasoline- and diesel-range hydrocarbons. A bentonite wall has been constructed along the riverbank for the majority of the site. A groundwater pump and treat system is in place and operating at the downstream end of the site where the cutoff wall is absent. Treatment of the source areas via air sparging is ongoing.

#### **RM 5.5**

Foss Maritime/Brix Marine – TPH releases from underground storage tanks (USTs) have been identified onsite. Contaminants include gasoline- and diesel-range hydrocarbons.

#### **RM 6**

NW Natural/Gasco – Groundwater plumes associated with historical MGP waste are known to be discharging to the river. Contaminants detected in groundwater include

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PAHs, SVOCs, VOCs (e.g., benzene, ethylbenzene, toluene and xylene – BTEX), cyanide, sulfide, sulfate and carbon disulfide, ammonia, and metals (aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, copper, iron, lead, magnesium, manganese, mercury, nickel, selenium, silver, thallium, vanadium, and zinc). Gasoline- range hydrocarbons, diesel- range hydrocarbons, residual-range hydrocarbons and total petroleum hydrocarbon fractions are being added to the groundwater monitoring program. A hydraulic control pump and treatment system has been constructed at the riverbank and is currently being tested.

#### **RM 6 and RM 7**

Siltronic – A chlorinated VOC plume as well as groundwater plumes associated with historical MGP waste and pesticide plumes from Rhone Poulenc are known to discharge to the river. Contaminants include petroleum-related and chlorinated VOCs (benzene, chlorobenzene, 1,2-dichlorobenzene, 1,3-dichlorobenzene, 1,1-dichloroethene, cis-1,2-DCE, trans-1,2-DCE, TCE, and vinyl chloride), PAHs, gasoline- range, diesel-range, and residual-range hydrocarbons, cyanide, metals (arsenic, barium, beryllium, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, silver, thallium, vanadium, and zinc), Silvex, and dichlorprop. In-situ bioremediation and treatment with zero-valent iron has been implemented to reduce halogenated VOC concentrations discharging to the river. The NW Natural hydraulic control pump and treatment system extends to the northern portion of the Siltronic site is expected to control the TCE plume in addition to the Gasco MGP plume.

#### **RM 7**

Rhone Poulenc – Known releases of organochlorine insecticides and herbicides, including PCP, 2,4-DP, Bromoxynil, 4(2,4-dichlorophenoxy)butyric acid (2,4-DB), 2-methyl-4-chlorophenoxyacetic (MCPA), methylchlorophenoxypropionic acid (MCP), 4-(4-chloro-2-methylphenoxy)butanoic acid (MCPB), 2,4,5-trichlorophenoxyacetic acid [2,4,5-T], 2,4-dichlorophenoxyacetic acid (2,4-D), DDT, Endrin, Heptachlor, sodium chlorate, sodium arsenate, 2,4,5-TP (Silvex), aldrin, dieldrin, chlordanes, and dichlorprop have occurred at the site

Spatial and temporal uncertainty present in the groundwater dataset for the site results in uncertainty in defining the full extent of the groundwater plume. DEQ determined that there is clear evidence that source control is needed to address direct discharge to the River of the following contaminants in groundwater: VOCs (e.g., dichlorobenzene isomers, and chlorobenzene), and herbicides (e.g., Silvex and dichlorprop). The plume is uncontrolled (ODEQ 2013).

The City Outfall 22B groundwater infiltration pathway is currently being addressed through implementation of the Outfall 22B Expanded IRAM. The Outfall 22B Expanded IRAM is being implemented to address exceedances of Joint Source

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Control Screening Level Values for the following in dry weather flow: SVOCs (2,4,6-trichlorophenol, 2,4-dichlorophenol, 2-methylphenol, pentachlorophenol, and naphthalene), Insecticides (aldrin, alpha-chlordane, dieldrin, gamma-chlorodane, heptachlor epoxide, hexachlorobenzene, DDD, DDE, and DDT), Dioxin/furans (2,3,7,8-TCDD) and metals (aluminum, boron, molybdenum, thallium, arsenic, barium, iron, manganese) (ODEQ 2013b).

Kinder Morgan Pump Station – A TPH plume has been identified at the pump station. The extent of the plume is currently unknown.

Arkema – Contaminants detected in groundwater at the site include, but are not limited to, DDT and its metabolites DDD and DDE (DDX) and VOCs (MCB, chloroform, PCE, TCE and benzene), perchlorate and hexavalent chromium). The DDX and MCB are primarily associated with pesticide manufacturing process residue (MPR). Perchlorate and hexavalent chromium are associated with the Chlorate Plant area. A barrier wall and groundwater pump and treat system is being constructed to manage the groundwater plumes on the southern end of the property and is currently being tested. Additional source control measures to address groundwater impacts north of the groundwater containment system will be evaluated in the Arkema upland FS.

RM 8 Kinder Morgan Willbridge Bulk Terminal – A TPH plume is not known to be currently discharging to the river. Contaminants include gasoline- range hydrocarbons, diesel- range hydrocarbons, residual-range hydrocarbons, and arsenic. Evaluation of the plume is ongoing.

Chevron and Unocal Willbridge Bulk Terminal – A TPH plume located onsite has discharged to the river. Contaminants include LNAPL, gasoline- range hydrocarbons, diesel- range hydrocarbons, residual-range hydrocarbons, and metals (arsenic and manganese). Nineteen control measures have been implemented at the site between the early 1970s and 2010 to address the potential migration of impacted groundwater to the Willamette River. Saturated petroleum hydrocarbon (SPH) contamination has been detected at various locations across the site. Observations of sheen associated with recent high groundwater conditions has raised concerns regarding the long-term adequacy of the LNAPL containment system; additional characterization is in progress, and it is expected that modifications to the LNAPL containment system will be proposed.

Chevron Asphalt Plant – Free product consisting of relatively immobile asphalt-related petroleum has been noted on site. Contaminants include TPH (diesel-range and gasoline-range hydrocarbons), arsenic, BTEX and naphthalene. DEQ has concluded that the plume is not discharging to the river.

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## **RM 9**

Gunderson – There is a chlorinated VOC plume (1,1-DCE, 1,1,1-trichloroethane [1,1,1-TCA], PCE, TCE and vinyl chloride) near the downstream end of the Gunderson property. An air sparge/soil vapor extraction and a pump and treat system were operating for the VOC plume. DEQ approved the shut-down of the pump and treat system and a rebound assessment is in progress.

In addition, there is a PAH groundwater plume located between the Equilon (Shell Terminal) pipeline gasoline release and the Equilon dock at Gunderson. The PAH plume was determined by DEQ to not be discharging to the river. Shell treated a gasoline release from their pipeline on the Gunderson site using an air sparge and vapor recovery system. This system has been shut down and dismantled. DEQ approved the cleanup and issued a NFA.

Christensen Oil – A TPH (Stoddard solvent) plume is located onsite. The plume extent is not known to currently discharge to the river since a dual phase extraction and treatment system is currently operating to control migration of the plume. Evaluation of the control is ongoing.

Univar – A VOC plume is located onsite. Contaminants include 1,1-DCA, 1,1-DCE, cis-1,2-DCE, methylene chloride, PCE, toluene, 1,1,1-TCA, TCE, vinyl chloride, and xylenes, . The plume does not extend to the river. Soil vapor extraction and pump and treat systems have been implemented as interim corrective measures.

Galvanizers Inc. – A zinc plume located at this site is not known to currently discharge to the river. The plume may have infiltrated the storm water system that discharged to the river; however, that system has been diverted to the City Big Pipe project.

## **RM 10**

Sulzer Pump – TPH, PAH, and VOC plumes from UST and waste oil UST releases exists at this site.

## **RM 11.5**

Centennial Mills – A TPH (diesel-range hydrocarbons) plume is located at this site. The plume is not known to discharge to the river, but may be infiltrating the Tanner Creek sewer line near the river.

### **1.2.3.5 River Banks**

Identification of contaminated banks is being managed by DEQ under an MOU with EPA. The following provides a discussion of the known contaminated banks:

1-20

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### **East Side of Willamette River**

#### **RM 2**

Evraz Oregon Steel Mill – Contaminants present in the riverbank includes PCBs and metals (arsenic, cadmium, chromium, copper, lead, manganese, and zinc). A source control measure to remove, cap and stabilize contaminated riverbank material is currently in the design phase.

#### **RM 3.5**

Schnitzer Steel Industries – Results of soils samples collected under the docks along the south shore of the International Slip indicate that contaminants are PCBs and dioxins.

#### **RM 5.5**

MarCom South – Further investigation of the nature and extent of contamination in the bank was conducted in 2012. Contaminants are PAHs and metals (arsenic, cadmium, chromium, copper, zinc).

#### **RM 7**

Willamette Cove - Riverbank contaminants are PCBs, dioxins/furans, metals (lead, mercury, nickel, and copper), and PAHs. Source control evaluation is currently ongoing.

#### **RM 8.5**

Swan Island Shipyard – Recent sampling results for OU1 indicate that contaminants include metals (arsenic, cadmium, chromium, copper, lead, mercury, and zinc), PAHs, PCBs, and tributyltin. Contaminants in river bank soils in OU5 include metals (arsenic, copper, lead, and zinc), PAHs, and PCBs. Source control evaluation is currently ongoing.

### **West Side of Willamette River**

#### **RM 4**

Kinder Morgan Linnton Bulk Terminal – Contaminants are petroleum constituents (BTEXs and PAHs) and metals (arsenic and lead).

#### **RM 6**

NW Natural/Gasco – Contamination associated with historical MGP waste are known to be located in the river bank. Contaminants include PAHs, gasoline- range hydrocarbons, diesel- range hydrocarbons, residual-range hydrocarbons, cyanide, and metals (zinc).

## RM 6 and RM 7

Siltronic – Contamination associated with historical MGP waste is known to be present in the northern portion of the Siltronic riverbank. Riverbank contaminants include PAHs, gasoline- range hydrocarbons, diesel- range hydrocarbons, residual-range hydrocarbon and cyanide and metals (zinc).

Burlington Northern and Santa Fe Railroad Bridge – Contamination associated with and pesticide and herbicide releases from Rhone Poulenc and Arkema are known to be present in the river bank below and adjacent to the Burlington Northern and Santa Fe railroad bridge. Riverbank contaminants include, dioxin/furans, metals (aluminum, antimony, arsenic, barium, beryllium, boron, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, molybdenum, nickel, potassium, selenium, silver, sodium, thallium, vanadium, zinc, Insecticides (DDD, DDE, DDT, aldrin, alpha-BHC, alpha-chlordane, beta-BHC, cis-nonachlor, delta-BHC, dieldrin, endosulfan I, endosulfan II, endosulfan sulfate, endrin, endrin aldehyde, endrin ketone, gamma0BHC, gammachlordane heptachlor, heptachlor epoxide, hexachlorobutadiene, methoxychlor, mirex, oxychlordane, and trans-nonachlor), PCBs, SVOCs (acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, benzoic acid, benzyl alcohol, bis (2-ethylhexyl)phthalate, butylbenzylphthalate, chrysene, bibenzo(a,h)anthracene, dimethylphthalate, bi0n-butylphthalate, fluoranthene, indeno(1,2,3-cd)pyrene, phenanthrene and pyrene). (AMEC 2011).

## RM 7

Arkema –Riverbank contaminants include DDT, dioxin/furans, PCBs, and metals (chromium and lead).

## RM 9

Gunderson –Contaminants include metals (lead, nickel, and zinc), and PCBs.

### 1.2.4 Feasibility Study Conceptual Site Model (CSM) Contaminant Fate and Transport

The CSM integrates the information gathered through extensive physical, chemical, and biological characterizations to provide a coherent hypothesis of the Site relevant to development of the FS, including current Site conditions, potentially unacceptable risks posed, and currently known or suspected ongoing sources. It is a refinement of the CSM presented in the final RI, Section 10 so that the CSM is more focused and useable for the draft FS. The draft FS CSM is summarized visually through three key figures:

- Figure 1.2-21, from the RI, provides an overall visual summary of currently known or suspected contaminant sources, fate and transport processes, and

**Commented [A1]:** EPA provided additional redlines to the Contaminant Fate and Transport section of the FS on August 25<sup>th</sup>, and requested that LWG review these redlines and add in any additional discussion necessary. LWG will provide these edits once available.

**Commented [A4]:** Fate and transport is one aspect of the FS CSM and should be incorporated as subsection to the CSM description.

contaminant interactions with humans and ecological receptors that result in potentially unacceptable risk.

- Figure 2.6-2 provides a visual summary of the major Site physical and contaminant conditions relevant to the draft FS.
- Figures 1.2-20a through 1.2-20c provide a visual summary of currently known or suspected contaminant source loads and the fate and transport of contaminants (in terms of loads) entering into, within and exiting from the Site.

**Commented [A2]:** Figure number will need to change for final edit. This is the figure number referenced from the draft FS for the figures to be added here.

#### **1.2.4.1 Physical Setting**

The Site is in a relatively low-energy depositional (facies) reach of the Lower Willamette River and the entire Willamette River Watershed. The sections of the river upstream (from approximately RM 11 to the Willamette Falls at RM 26) and downstream of the Study Area (RM 1.9 to the Columbia River) are narrower than the Study Area, and the Multnomah Channel exits the Lower Willamette River at RM 3, reducing the Lower Willamette River discharge downstream of this point. This physical configuration and the associated hydrodynamic interactions result in deposition and accumulation of sediments in much of the Study Area, particularly from RM 2 to 3 and RM 7 to 11 (i.e., bathymetry measurements indicate 88 percent of the Study Area is depositional or shows no substantial change over the period measured). This creates prominent channel shoals from RM 2 to 3 and RM 8 to 10 (Figure 2.6-2). Some channel segments are more dynamic, and localized areas in these regions exhibit both net erosion as well as net deposition (Figure 2.6-2). Nearshore and off-channel areas are generally depositional. Some of the nearshore areas where vessels transit to nearshore docks are subject to anthropogenic sediment resuspension (e.g., vessel propwash); removal of sediments through maintenance dredging may also occur in these areas (indicated by Future Maintenance Dredge areas in Figure 2.6-2). Since 1997, selective maintenance dredging has been performed in the federal navigation channel. Very close to shore in shallower water, sediment resuspension from wind and vessel wake generated waves occurs (Figure 2.6-2). These off-channel areas tend to have a higher incidence of debris (which can complicate sediment remediation implementation) in and on the surface sediment. Shoreline areas have numerous structures and other anthropogenic features, which are important factors in determining remedial alternative feasibility (Figure 2.6-2).

#### **1.2.4.2 Chemical Distribution**

Elevated concentrations of contaminants in the Study Area are typically associated with areas near currently known or likely historical and/or existing sources. Figure 2.6-2 shows the surface sediment areas (i.e., AOPCs, see Section 3) that most often exceed a range of sediment PRGs (described more in Section 2). Although the highest sediment

**Commented [A3]:** To further support the CSM discussion here, EPA should include draft FS information on subsurface contamination (i.e., figures showing subsurface contamination distributions, biota tissue chemical concentrations, and TZW concentrations).

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concentration levels for the bounding ICs<sup>3</sup> are found in nearshore areas, somewhat elevated levels of the bounding ICs are found in the higher energy portion of the channel in the middle of the Study Area (RM 5 to 7). This may reflect past or current dispersal of material away from nearshore source areas. Throughout the Study Area, contaminant concentrations are generally higher in subsurface sediments than in surface sediments, indicating both higher historical contaminant inputs and improving sediment quality over time. Localized exceptions to the pattern of higher subsurface sediment concentrations exist in a few areas for some contaminants, likely reflecting more recent releases and/or disturbances of bedded sediments. Also, the depth of subsurface contamination is generally greater in nearshore areas as compared to the navigation channel.

As discussed in Section 1.2.3.2, areas with elevated contaminant concentrations in surface sediments generally correspond to areas of elevated subsurface sediment contaminant concentrations, particularly in nearshore areas. Areas where only surface or subsurface sediments exhibited elevated concentrations of contaminants point to spatially and temporally variable inputs and sources, or to different influences from sediment transport mechanisms. The PCB distributions in areas of elevated PCB concentrations are generally distinct from those in surrounding areas of lower PCB concentrations. Within areas of elevated PCB concentrations, the PCB patterns in surface and subsurface sediment, sediment traps, and in the particulate portion of the surface water samples are often similar. A similar pattern and similar composition across media was observed to a lesser degree for PAHs, but was less apparent for dioxins/furans or DDx compounds.

Most areas of elevated contaminant concentration in bedded sediment are located in relatively stable nearshore areas, and large-scale downstream migration/dispersal of concentrated contaminants from these areas is not indicated by the bedded sediment data. Much larger historical direct discharges from upland and overwater sources, rather than reworking of bedded sediments, are believed to have produced some of the observed patterns. Limited ongoing downstream dispersal of contaminants in sediments is suggested based on bedded sediment concentration gradients downstream of areas with elevated sediment concentrations.

#### **1.2.4.3 Sources, Fate, and Transport**

Most of the sediment contamination at the Site is associated with known or suspected historical sources and practices that have largely been discontinued or otherwise controlled. As discussed in Section 1.2.2, historical industrial activities and facilities in

<sup>3</sup> The bounding ICs are PCBs, DDx compounds, dioxin/furans, and PAHs, which bound most of the distribution of all contaminants found to potentially pose unacceptable risk in the baseline risk assessments.

the Site and upriver areas date back to the late 1800s and included a variety of industrial and other urban activities. These historical activities have primarily contributed to the current contaminants observed in sediments and associated risks discussed in the next subsection. However, more important to an FS is determining the current locations of unacceptable contaminant concentrations and current ongoing sources that may: 1) maintain unacceptable in-river contaminant levels; and/or 2) potentially contribute to unacceptable sediment or water recontamination after sediment remedies are performed. The RI/FS has catalogued or estimated historical and current sources of contaminants to the Study Area; however, not all sources have been identified.

Of the bounding ICs, for PCBs and DDx, the main external ongoing sources quantified for the FS are upstream surface water inputs encompassing all upstream watershed sources, and at the Study Area, to a much lesser extent, local stormwater (Figure 1.2-20). This association is likely true for other persistent bioaccumulative compounds that were not quantified here, some of which, like dioxin/furans, are secondary contributors to potential Site risks. Although the mass of PCBs and similar compounds entering the Site from upstream is relatively large (due to the large flow volume of the river), the concentration of these contaminants in upstream suspended sediments in surface water entering the Site is relatively low compared to current bedded sediment concentrations in portions of the Site posing the greatest potential risks. The concept of high loads, relative to other sources, and simultaneously low in-river concentrations in the Study Area appears to be true for both the upstream surface water and within Study Area stormwater inputs. Contaminant fate and transport modeling results discussed later in this FS and in Appendices Ha and Hb indicate that the influence of stormwater loads on surface water concentrations is quickly attenuated across and downstream through the Study Area due to the large volume of flows in the river. However, stormwater sources may have localized impacts on bedded sediment concentrations, although this effect is difficult to quantify on the scale of the entire Site. Some unquantified sources (e.g., bank erosion) may also be important in localized areas.

The high load/low concentration inputs, particularly of upstream surface water and stormwater, likely account for the lower concentrations of PCBs, DDx, and dioxins/furans in bedded sediments (which are comparable to upriver bedded sediment levels) seen across much of the Study Area, while the distribution of elevated concentrations of these contaminants in sediments in several nearshore portions of the Study Area appears to reflect more significant historical localized lateral inputs.

For PAHs, contaminant fate and transport model results for naphthalene and BaP represent sources, fate, and transport for low molecular weight PAHs (LPAHs) and high molecular weight PAHs (HPAHs), respectively (Appendix Ha). External sources differ substantially for LPAHs and HPAHs. For LPAHs (e.g., naphthalene), the main external ongoing sources are advection from subsurface sediment to surface sediment, upstream

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surface water inputs encompassing all upstream watershed sources, and local groundwater plumes. For HPAHs (e.g., BaP), the external ongoing sources quantified for the FS are all relatively minor, with upstream surface water inputs being the largest. For BaP, the model results indicate that internal transport processes (primarily sediment erosion and sediment porewater exchange with the water column) represent the largest sources of BaP to the Study Area (Figure 1.2-20).

The magnitude of various internal fate and transport processes for contaminants within the Study Area is summarized in Figure 1.2-20. The major internal fate and transport processes are erosion from the sediment bed, deposition to the sediment bed, dissolved flux from the sediment bed (porewater exchange), groundwater advection, degradation for some contaminants, volatilization to the air, and downstream transport of either particulate or dissolved phase associated contaminants. These processes interact to create potentially complex patterns of contaminant redistribution within the Study Area that are not easily described because they vary over space, time, and by contaminant. However, they can be estimated through the contaminant fate and transport modeling for different classes of contaminants (Appendix Ha). As noted above, patterns of bedded surface sediment contamination suggest some redistribution of contaminants over time from past source areas, but this is limited by ongoing burial of much of the source area contamination (as indicated by higher subsurface sediment concentrations in these areas). It should be noted that there is little in the empirical information from sediment contaminant profiles or fate and transport modeling results to suggest that buried contamination is a substantial or ongoing source to surface sediment contamination, through dissolved phase advection or any other process, over the vast majority of the Study Area. In some limited cases, periodic erosion may have the potential to temporarily expose buried contamination. Most evidence supports that sediment deposition acts like a natural cap to much of the buried contamination over much of the Site (with localized exceptions). Groundwater plume advection and release has been observed in a few areas and appears to be a relatively important process for certain LPAHs (e.g., naphthalene) in some locations along with dissolved phase flux from surface sediments to the water column. Also, per the RI some other groundwater-sourced contaminants have the potential to create in-river risk in specific localized areas, which indicates the need for upland groundwater source controls at those specific sites. In addition, RI surface water data suggest that resuspension and/or dissolved phase flux from the sediment bed are contributing to elevated contaminant levels in surface water, particularly in quiescent areas where surface water mixing and dilution is reduced. Loading estimates presented in Figure 1.2-20 are consistent with this concept, indicating the mass flux of contaminants exiting the downstream end of the Study Area in surface water (either directly to the Columbia River or via Multnomah Channel) is greater than the flux entering the Study Area. Stormwater inputs appear to be a relatively minor factor in determining in-river surface water

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concentrations except at RM 3 to 4 (International Slip) in the case of PCBs. Stormwater loading for PCBs at RM 3 to 4 east is primarily responsible for the increased surface water flux in this region of the Site.

Finally, both empirical tissue contaminant data and food web modeling (Appendix Hb) indicate that persistent contaminants (particularly PCBs and dioxin/furans) in sediments and surface water are bioaccumulated in aquatic species tissue. Given the contribution of sediment contaminants to surface water contaminant levels within the Site, determining the exact contribution of sediment versus surface water contaminants to tissue is a complex exercise. The food web modeling indicates fish tissue concentrations will decline over time as sediment concentrations decline. Active sediment remediation is anticipated to yield lower tissue concentrations than achieved solely by this expected natural recovery process in some segments of the Site.

Most of the sediment contamination at the Site is associated with known or suspected historical sources and practices. Ongoing sources of contamination include contaminated groundwater plumes, river bank soils, stormwater and upstream surface water. The distribution of contaminants in sediments in several nearshore areas appears to reflect more significant historical lateral inputs. The spatial correlation between PCBs in aquatic organisms and sediments indicate that contamination in bottom sediments are an ongoing source of persistent bioaccumulative contaminants such as PCBs, DDX and dioxin/furans contamination to biota. As concluded in Section 10 of the RI, empirical tissue contaminant data and food web modeling indicate that persistent contaminants (particularly PCBs and dioxin/furans) in sediments and surface water bioaccumulate in aquatic species tissue.

Internal contaminant fate and transport processes are those processes that affect the fate, transport and redistribution of contaminants within the study area. The major internal fate and transport processes are:

- Erosion from the sediment bed
- Deposition to the sediment bed
- Dissolved flux from the sediment bed (porewater exchange)
- Groundwater advection
- Degradation (for some contaminants)
- Volatilization

**Commented [A5]:** Food Web Modeling is not discussed in Section 10 of the RI. These biological data have not been discussed at all up to this point, and the draft FS information on contaminants in biota was deleted. This provides one example of how removing critical information from Section 2 of the draft FS has immediate impacts on the ability for even fundamental FS concepts to be clearly discussed and presented.

- Downstream transport of either particulate bound or dissolved phase contaminants

These processes interact to create complex patterns of contaminant redistribution that vary over space, time, and by contaminant. A discussion of fate and transport modeling for different classes of contaminants, which estimated the magnitude of various processes within the Study Area, is presented in the RI. In addition, Empirical estimates of contaminant loading associated with internal and external contaminant sources were developed during the RI. External sources include upstream loading (via surface water and sediment bedload), “lateral” external loading such as stormwater runoff permitted discharges (point source, non-stormwater), upland groundwater (contaminant plume transport to river), atmospheric deposition (to the river surface), direct upland soil and riverbank erosion, otherwise uncontaminated groundwater advection through contaminated subsurface sediments (chemical partitioning from subsurface sediment to pore water and advection to the surface sediment interval), and overwater releases. Internal sources include surface sediment loading to the surface water via sediment erosion (resuspension) and sediment porewater exchange (chemical partitioning from surface sediment to porewater and advection to surface water), as well as sinks.

Figures 1.2-202a through 1.2-202e provides a visual summary of currently known or suspected contaminant source loads within and exiting from the Site for three representative contaminants: total PCBs, benzo(a)pyrene, and DDE.

Elevated concentrations of contaminants in the Study Area are typically associated with areas near currently known or likely historical and/or existing sources. Although the highest sediment concentration levels for the indicator contaminants are found in nearshore areas, somewhat elevated levels of the bounding indicator contaminants are found in the higher energy portion of the channel in the middle of the Study Area (RM 5 to 7). This may reflect past or current dispersal of material away from nearshore source areas. Throughout the Study Area, contaminant concentrations are generally higher in subsurface sediments than in surface sediments, indicating both higher historical contaminant inputs and improving sediment quality over time (see final RI and draft FS Section XX for more detail on sediment trends over time). Localized exceptions to the pattern of higher subsurface sediment concentrations exist in a few areas for some contaminants, likely reflecting more recent releases and/or disturbances of bedded sediments. Also, the depth of subsurface contamination is generally greater in nearshore areas as compared to the navigation channel (see Section XX).

Areas with elevated contaminant concentrations in surface sediments generally correspond to areas of elevated subsurface sediment contaminant concentrations, particularly in nearshore areas. Areas where only surface or subsurface sediments

**Commented [A6]:** Language added regarding internal and external sources which is important to the FS. Need to discuss further F&T model.

**Commented [A7]:** Empirical loading estimates were presented in the RI. Modeling supporting development of the referenced figures was only conducted for and presented in the draft FS. It is unclear where and when this modeling is going to be discussed in the early sections of the FS, which it should be.

Fate and transport modeling was not discussed in the RI.

~~exhibited elevated concentrations of contaminants point to spatially and temporally variable inputs and sources, or to different influences from sediment transport mechanisms. Per the RI, the PCB distributions in areas of elevated PCB concentrations are generally distinct from those in surrounding areas of lower PCB concentrations. Within areas of elevated PCB concentrations, the PCB patterns in surface and subsurface sediment, sediment traps, and in the particulate portion of the surface water samples are often similar. A similar pattern and similar composition across media was observed to a lesser degree for PAHs, but was less apparent for dioxins/furans or DDX compounds.~~

~~Most areas of elevated contaminant concentration in bedded sediment are located in relatively stable nearshore areas, and large scale downstream migration/dispersal of concentrated contaminants from these areas is not indicated by the bedded sediment data. Much larger historical direct discharges from upland and overwater sources, rather than reworking of bedded sediments, are believed to have produced some of the observed patterns (e.g., elevated levels in subsurface sediments downstream of the source areas). Limited ongoing downstream dispersal of contaminants in sediments is suggested based on bedded sediment concentration gradients downstream of areas with elevated sediment concentrations. Elevated concentrations of contaminants in the Study Area are typically associated with areas near currently known or likely historical and/or existing sources. Although the highest sediment concentration are generally found in nearshore areas, elevated levels of contamination are also found in the higher energy portion of the channel in the middle of the Study Area (RM 5 to 7). This may reflect past or current dispersal of material away from nearshore source areas. Throughout the Study Area, contaminant concentrations are generally higher in subsurface sediments than in surface sediments, indicating both higher historical contaminant inputs and improving sediment quality over time. Localized exceptions to the pattern of higher subsurface sediment concentrations exist in a few areas for some contaminants, likely reflecting more recent releases and/or disturbances of bedded sediments. Also, the depth of subsurface contamination is generally greater in nearshore areas as compared to the navigation channel.~~

~~Areas with elevated contaminant concentrations in surface sediments generally correspond to areas of elevated subsurface sediment contaminant concentrations, particularly in nearshore areas. Areas where only surface or subsurface sediments exhibited elevated concentrations of contaminants point to spatially and temporally variable inputs and sources, or to different influences from sediment transport mechanisms. Per the RI, the PCB distributions in areas of elevated PCB concentrations are generally distinct from those in surrounding areas of lower PCB concentrations. Within areas of elevated PCB concentrations, the PCB patterns in surface and subsurface sediment, sediment traps, and in the particulate portion of the surface water~~

**Commented [A8]:** EPA requested that LWG revise Section 1.2.4 to be more clear.

The text below is cut and pasted from the Draft FS, with placeholders for references to future FS sections.

The text addition below paraphrases this text and makes it difficult to understand.

However - with most of the supporting information on sediment deposition and erosion patterns deleted, this text all appears as conjecture. This is another example where information supporting CSM discussions is needed.

Per EPA request, LWG is working on additional text for this section.

samples are often similar. A similar pattern and similar composition across media was observed to a lesser degree for PAHs, but was less apparent for dioxins/furans or DDx compounds.

Most areas of elevated contaminant concentration in bedded sediment are located in relatively stable nearshore areas, and large-scale downstream migration/dispersal of concentrated contaminants from these areas is not indicated by the bedded sediment data. Much larger historical direct discharges from upland and overwater sources, rather than reworking of bedded sediments, are believed to have produced some of the observed patterns (e.g., elevated levels in subsurface sediments downstream of the source areas). Limited ongoing downstream dispersal of contaminants in sediments is suggested based on bedded sediment concentration gradients downstream of areas with elevated sediment concentrations.

Patterns of contamination in bedded surface sediment suggest some redistribution of contaminants over time from past source areas, but this is limited by reburial of much of the source area contamination (as indicated by higher subsurface sediment concentrations in these areas). Periodic erosion may temporarily expose buried contamination.

Groundwater plume discharge to surface water advection and release has been observed in several areas along with dissolved phase flux from surface sediments to the water column has been inferred from RI data.

Based on results of surface water data collected during the RI, resuspension and/or dissolved phase flux from the sediment bed are contributing to contaminant concentrations in surface water, particularly in quiescent areas where surface water mixing and dilution is minimal. Loading estimates presented in Figures 1.2-202a through 1.2-202c are consistent with this concept, indicating the mass flux of contaminants exiting the downstream end of the Study Area in surface water (either directly to the Columbia River or via Multnomah Channel) is greater than the flux entering the Study Area.

Contaminant concentrations in loads stormwater entering the Study Area from adjacent upland sources and pathways (such as stormwater) are generally greater than concentrations associated with upstream surface water. However, from a loading perspective, lateral contaminated loads associated with upland sources are comparable to upstream loads for key certain contaminants including in the upstream loads (upriver surface water and sediments). Stormwater input is the most important current source pathway within the Study Area for many contaminants, including PCBs and DDx.

Commented [A9]: Accept edit.

Commented [A10]: Agreed.

Commented [A11]: Agreed.

Commented [A12]: Accept edits.

Commented [A13]: This is still not correct for DDx. The mass loading evaluation in the RI shows that outside study area/upstream sources account for a much larger mass of DDx than is contributed from all of the study area.

For example, the last paragraph of page 10-18 of EPA's RI Section 10 states: "The most significant current influx of DDx to the Study Area is upstream surface water, and is associated with both the dissolved and suspended particulate fraction." Note that the wording "contaminant concentrations in loads" is incorrect. Concentrations and loads are distinct concepts that should not be conflated in this way. Because a loading figure is supporting this discussion, the text should stick to a discussion of loads, not concentrations.

Groundwater plume discharge to surface water has been observed in several areas. Dissolved phase flux from surface sediments to the water column has been inferred from RI data.

Commented [A14]: Agreed.

Commented [A15]: Agreed.

Commented [A16]: Accept edits.

Finally, empirical tissue contaminant data and food web modeling indicate that persistent contaminants (particularly PCBs and dioxin/furans) in sediments and surface water bioaccumulate in aquatic species tissue.

Commented [A17]: Accept edit.

The CSM integrates the information gathered to date to provide a coherent hypothesis of the Site fate and transport. Figure 1.2-213 provides a general overall visual summary of this hypothesis, including contaminant interactions with human and ecological receptors.

Commented [A18]: Accept edit.

#### 1.2.4.4 Biological and Habitat Setting

The landscape of the Lower Willamette River watershed and the heavily industrialized condition of the Site are significant drivers of the biological communities and habitats found there. Upstream activities; extensive dredging, channelization, and filling; and introduced species have significantly altered the ecosystem, ecological processes, and the biological community structure (Integral et al. 2011; Sanderson et al. 2009). For example, over the last 100 years or so, approximately 79 percent of the shallow water habitat within the Lower Willamette River has been lost through historic channel deepening (WRI 2004). However, the Site includes some habitat areas that support fish and wildlife species described below.

Commented [A19]: Per Issue 1 in LWGs 8/25/14 major issues summary, although EPA retained some references to a few CSM fate and transport processes, the bulk of the Draft FS CSM description was removed. Critical CSM information for FS alternative development and evaluation that was removed includes, but is not limited to, the following: 1) physical factors and processes (e.g., descriptions of bathymetry, deposition/erosion, debris, substrate types, and shoreline conditions); 2) site uses (e.g., channel and maintenance dredging areas); 3) human activities (e.g., vessel traffic patterns, propwash, and historical remediation); 4) chemical distributions; 5) biological habitats and restoration sites; 6) site sources; and 7) potential risks. EPA's CSM focuses on a cartoon from the draft FS, which is insufficient to convey the existence and interplay of these various CSM factors (as compared to the detailed CSM maps in Draft FS Figure 2.6-2, which were deleted).

The Lower Willamette River supports numerous aquatic and semi-aquatic organisms, including aquatic plants, invertebrates, fishes, amphibians, reptiles, birds, and mammals. The benthic invertebrate community within the Lower Willamette River is dominated by small organisms that live on or in the sediment and include an abundance of oligochaetes, chironomids, amphipods, polychaetes, and clams. The Lower Willamette River is also an important rearing and migration corridor for anadromous fish, such as salmon and lamprey. It provides habitat for more than 40 species of resident fish, both native and non-native (based on both historical and recent studies (Windward 2011)). Numerous aquatic-dependent bird species (more than 20 species commonly occur based on available information, including cormorants, spotted sandpiper, osprey, and bald eagle) use habitats within the Lower Willamette River (Windward 2011). These birds include herbivores, carnivores and omnivores, sediment-probing insectivores and omnivores, and piscivores. Six aquatic or semi-aquatic mammals have been identified that use or may use the Lower Willamette River, including opportunistic piscivores, such as mink (Windward 2011). The Lower Willamette River includes few submerged and emergent plant communities; and, thus, provides limited habitat for amphibians and reptiles.

Habitat types in the Site are the result of extensive modifications in the Lower Willamette River as described above, including loss of shallow water habitats and impairment of existing habitat functions as compared to historical, natural conditions. Also, the Lower Willamette River is constrained by upstream management of flows (ODFW 2010; NMFS 2008) by 13 federal reservoirs that alter the timing and magnitude of flows resulting in downstream impacts to fish habitat (ODFW 2010; Fresh et al. 2005). As a result of these habitat modifications, species including otter, mink, and juvenile salmonids that prefer the slower water velocities, foraging opportunities, and cover and refugia provided by shallow water and off-channel habitats are confined to relatively narrow strips of shallow water habitat between the shoreline and navigational channel. There are several shallow water habitat pockets remaining in the Lower Willamette River including Willamette Cove, the head of Swan Island Lagoon, the mouth and channel of Multnomah Channel, and the Sauvie Island shoreline (Integral et al. 2011).

For the purposes of evaluating the FS alternatives the Site can be divided into four different habitat zones based on water depths similar to those identified by the Portland Harbor Natural Resource Trustees Natural Resource Damage Assessment process (PHNRT 2008, 2010):

- Active Channel Margin (ACM) – This zone is periodically inundated and available to aquatic species. It extends from above the upper Site boundary elevation of +13 feet NAVD88 to the lower edge of persistent woody vegetation at approximately +5 feet NAVD88. This zone has high habitat value for numerous aquatic species, but the areal extent of ACM within the Study Area is very limited due to channelization of the river.
- Shallow Water Zone – This zone extends from +5 to -4.9 feet NAVD88, and the upper elevations of this zone are seasonally available to aquatic species while the lower elevations are continually available. It has high habitat value and is important to the growth and survival of aquatic organisms, but the areal extent of this zone is also relatively limited within the Study Area.
- Main Channel Shallow Water Zone – This zone extends from -4.9 to -14.9 feet NAVD88, which is continually available to aquatic species. This zone generally has lesser habitat value than the ACM and shallow zones for a variety of species, but is still important for various life stages of many aquatic species.
- Deep Water Zone – This zone is defined as the aquatic area deeper than -14.9 feet NAVD88. This zone is continually available to aquatic species and covers the largest amount of area in the Study Area. It has the lowest general habitat value as compared to the other zones, although it contributes to benthic

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production, and other species within the food web utilize this area for forage (e.g., crayfish, sturgeon, and carp).

In addition to water depths, physical characteristics including substrate and presence of overwater structures and shoreline armoring are also important in defining habitats for many species. Shallow water habitats with fine-grained substrates provide important foraging opportunities for aquatic species due to presence of benthic macroinvertebrates, zooplankton, and emergent insects (NMFS 2008). Overwater structures, which exist as mainly dock structures throughout the Study Area, may affect the primary and epibenthic productivity within the nearshore habitat. Figures 2.3-1 and 2.3-2 show the locations of primary habitat characteristics of water depths, substrate types, shoreline types, and overwater structures within the Study Area. Based on this mapping exercise, there are approximately 80 acres of ACM and 290 acres of shallow water high value habitat areas within the Site that provide suitable forage opportunities and other habitat functions.

**Commented [A20]:** We suggest that these figures be returned to FS Section 1 or at least referenced to some other location like an Appendix.

#### 1.2.4.1.1.2.4.5 **Current and Likely Future Risk**

**Figure 1.2-21** depicts how people and ecological receptors in the Site may interact with the contaminants discussed in the previous sections resulting in potentially unacceptable risks that exceed EPA target levels in some cases. This section presents a summary of the results of the baseline human health and ecological risk assessments (BHHRA and BERA). These assessments are presented in Appendices F and Appendix G of the RI report.

#### 1.2.4.1.1.2.4.5.1 **Baseline Human Health Risk Assessment**

The BHHRA presents an analysis of the potential for effects associated with both current and potential future human exposures at Portland Harbor. Potential exposure to contaminants found in environmental media and biota was evaluated for various occupational and recreational uses of the river, as well as recreational, subsistence, and traditional and ceremonial tribal consumption of fish caught within the Portland Harbor site. Additionally, because of the persistent and bioaccumulative nature of many of the contaminants found in sediment, infant consumption of human breast milk was also quantitatively evaluated.

The specific populations and exposure pathways evaluated were:

- Dockside workers — direct exposure via incidental ingestion and dermal contact with beach sediments.
- In-water workers — direct exposures to in-water sediment.
- Transients — direct exposure to beach sediment, surface water for bathing and drinking water scenarios, and groundwater seeps.

- Recreational beach users — direct exposure to beach sediment and surface water while for swimming.
- Tribal fishers — direct exposure to beach or in-water sediments, and consumption of migratory and resident fish.
- Recreational and subsistence fishers — direct exposure to beach or in-water sediments, consumption of resident fish, and consumption of shellfish.
- Divers — direct exposure to in-water sediment and surface water.
- Domestic water user — direct exposure to untreated surface water potentially used as a drinking water source in the future.
- Infant consumption of human breast milk—exposure to certain persistent and bioaccumulative contaminants (polychlorinated biphenyls [PCBs], dichlorodiphenyldichloroethane, dichlorodiphenyldichloroethylene, and dichlorodiphenyltrichloroethane [DDx] compounds, dioxins and furans, and polybrominated diphenyl ethers [PBDEs]) via nursing infants of dockside and in-water workers, divers, and recreational, subsistence, and tribal fishers.

Consistent with EPA policy, the BHHRA evaluated a reasonable maximum exposure (RME), which is defined as the maximum exposure that is reasonably expected to occur. In addition, estimates of central tendency (CT), which are intended to represent average exposures, were also evaluated. **Figure 1.2-22** presents the conceptual site model for the BHHRA.

Cancer risk and noncancer hazard from site-related contamination was characterized based on current and potential future uses at Portland Harbor, and a large number of different exposures scenarios were evaluated. Based on 2002 and 2007 fish tissue data, exposure to bioaccumulative contaminants (PCBs, dioxins/furans, and organochlorine pesticides, primarily DDx compounds) via consumption of resident fish consistently poses the greatest potential for human exposure to in-water contamination. Scenarios for which the cumulative estimated cancer risk is greater than  $1 \times 10^{-4}$  or the HI is greater than 1 are consumption of fish and shellfish, and direct contact with in-water sediment by tribal and high frequency fishers. The major findings of the BHHRA are:

- Estimated cancer risks resulting from the consumption of fish or shellfish are generally orders of magnitude higher than risk resulting from direct contact with sediment and surface water. Risks and noncancer hazards from fish and shellfish consumption exceed the EPA point of departure for cancer risk of  $1 \times 10^{-4}$  and target hazard index (HI) of 1 when evaluated on a harbor-wide basis, and when evaluated on the smaller spatial scale by river mile.

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- Consumption of resident fish species consistently results in the greatest risk estimates. Evaluated harbor-wide wide, the estimated RME cancer risks are  $4 \times 10^{-3}$  and  $1 \times 10^{-2}$  for recreational and subsistence fishers, respectively.
- Noncancer hazard estimates for consumption of resident fish species are greater than 1 at all river miles. Based on a harbor-wide evaluation of noncancer risk, the estimated RME HI is 300 and 1,000 for recreational and subsistence fisher, respectively. The highest hazard estimates for recreational fishers are at RM 4, RM 7, RM 11, and in Swan Island Lagoon.

The highest noncancer hazards are associated with nursing infants of mothers, who consume resident fish from Portland Harbor. When fish consumption is evaluated on a harbor-wide basis, the estimated RME HI is 4,000 and 10,000 for breastfed infants of recreational and subsistence fishers, respectively. Evaluated on a harbor-wide scale, the estimated RME HI for tribal consumers of migratory and resident fish is 600 assuming fillet-only consumption, and 800 assuming whole-body consumption. The corresponding HI estimates for nursing infants of tribal mothers, who consume fish, are 8,000 and 9,000 respectively, assuming maternal consumption of fillet or whole-body fish.

These risk estimates are based on specific assumptions regarding fish consumption practices within Portland Harbor. Recreational fishers are assumed to consume 49 grams per day (approximately 6.5 eight ounce meals per month) of a multi-species diet consisting of resident fish fillet with skin tissue for 30 years; subsistence fishers are assumed to consume 142 grams per day (approximately 19 eight ounce meals per month) of a multi-species diet consisting of resident fish fillet with skin tissue for 30 years; and tribal fishers are assumed to consume 175 grams per day (approximately 23 eight ounce meals per month) of a multi-species diet consisting of migratory and resident fish whole body or fillet with skin tissue for 70 years. The risk estimates do not account for effects from preparation or cooking the fish. For a breastfeeding infant, it is assumed that the maternal consumption of fish prior to birth of the infant is the same as described for the fishers.

- PCBs are the primary contributor to risk from fish consumption harbor-wide. When evaluated on a river mile scale, dioxins/furans are a secondary contributor to the overall risk and hazard estimates, and pose the highest risk at RM 7. PCBs are the primary contributors to the noncancer hazard to nursing infants, primarily because of the bioaccumulative properties of PCBs and the susceptibility of infants to the developmental effects associated with exposure to PCBs.

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- The greatest source of uncertainty in the risk and hazard estimates includes the lack of site-specific information about consumption of resident fish from Portland Harbor. Because tribal fish consumption practices were evaluated assuming a combined diet consisting of both resident and migratory fish, it is not clear to what degree contamination in Portland Harbor contributes to those estimated risks. In addition, it is important to remember that the noncancer hazard estimates presented in the BHHRA are not predictions of specific disease, and the cancer estimates represent upper-bound values, and the EPA is reasonably confident that the actual cancer risks will not exceed the estimated risks presented in the BHHRA.

#### ~~1.2.4.1-1.2.4.5.2~~ Baseline Ecological Risk Assessment

The BERA presents an evaluation of risks to aquatic and aquatic-dependent species within the Study Area in the absence of any actions to control or mitigate contaminant releases. The overall process used for the BERA was based on the guidance provided in the *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments – Interim Final* (EPA 1997c) and followed the approach documented in numerous interim deliverables as well as discussions, directives, and agreements with the LWG, EPA and its federal, state, and tribal partners. **Figure 1.2-23** presents the conceptual site model for the BERA.

Sediment toxicity tests were performed to evaluate adverse effects of Portland Harbor sediment on survival and biomass of larvae of the aquatic insect *Chironomus dilutus* and juveniles of the amphipod *Hyaella azteca*. These toxicity tests demonstrated that the exposure of these animals to sediment from some locations within Portland Harbor resulted in increased mortality and/or reduced biomass of these two species within 10 to 28 days – a direct measure of sediment toxicity to benthic invertebrates within the Portland Harbor Study Area. The moderate and severe levels of toxicity were not randomly scattered throughout the Study Area. Instead, most samples and locations eliciting multiple instances of moderate and severe toxicity tended to be clustered in several areas, especially areas between RM 5.9 and RM 7.8. Other areas with “clusters” of benthic toxicity included International Slip; between RMs 3.7 and 4.2 on the west side of river; between RMs 4.8 and 5.2 on the west side of river; Willamette Cove; near the mouth of Swan Island Lagoon; and between RMs 8.7 and 8.8 on the west side of river. A weight-of-evidence analysis identified 17 benthic areas of concern (AOCs) within the Study Area. Combined, the above areas can be estimated to cover between 4 and 8% of the total surface area of sediment within the Study Area.

Aside from the toxicity testing used to characterize risks to the benthic community, most risk characterizations in the BERA were made using the hazard quotient (HQ). An HQ is calculated by dividing the exposure estimate by an effects threshold. COPCs

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for which the HQ was  $\geq 1.0$  were identified as contaminants posing potentially unacceptable risk at the conclusion of the BERA. The potential for unacceptable risk becomes increasingly large as the HQ value increases, although the increase is not necessarily linear (e.g., a sample with an HQ = 2.0 does not necessarily have twice the risk of a sample with an HQ = 1.0).

In ERAs, the ecological significance of the identified risks is determined by evaluating if the risks will make an observable difference in light of other factors that are influencing the environment, such as habitat alteration.

With the exception of species protected by law or regulation (e.g., threatened and endangered species) for which individual organisms are protected, EPA guidance and policy state that ERAs should generally focus on the protection of local populations and communities of biota (e.g., the Study Area population of smallmouth bass, not the global population of smallmouth bass, which exists on four continents). Oregon's ERA guidance (ODEQ 1998) defines a local population for a stream or river as follows, "For aquatic species in moving water such as streams and rivers (lotic habitats), the local population comprises all individuals of the endpoint species within the stream segment within the contaminated area."

Ecological significance can be defined as the importance of an adverse effect on population, community, or ecosystem responses. Factors contributing to ecological significance considered in the BERA included the nature and magnitude of effects, the spatial and temporal extent of effects, uncertainties in the exposure assessment, uncertainties in the effects characterization, and concordance of the various LOEs used to assess risk to communities or populations.

The LWG and EPA separately evaluated the ecological significance of the identified risks and drew independent conclusions. Both parties found that PCBs, PAHs, dioxins and furans, and total DDx are ecologically significant contaminants at Portland Harbor. EPA identified several additional contaminants that it considers most likely to be ecologically significant contaminants

The following presents the primary conclusions of the BERA.

- In total, 93 contaminants (as individual contaminants, sums, or totals)<sup>4</sup> with HQ  $\geq 1.0$  pose potentially unacceptable ecological risk. Differences in the specific

<sup>4</sup> The five chemicals or chemical groups with concentrations that exceeded only the sediment probable effects concentration (PEC) and/or probable effects level (PEL) (i.e., chemicals that were not identified as COPCs for other benthic invertebrate LOEs: Aroclor 1254, chlordane [cis and trans], gamma-hexachlorocyclohexane [HCH] [Lindane], heptachlor epoxide, and total chlordane), ammonia and sulfide (which are conventional parameters),

toxicity reference values (TRVs) used in different lines of evidence (LOEs) for total PCBs (e.g., total PCBs versus specific Aroclor mixtures), total DDx, and total PAHs, all of which describe individual contaminants or a group of multiple but related individual chemical compounds, can result in different counts of the number of contaminants posing potentially unacceptable risk. The list of contaminants posing potentially unacceptable risks can be condensed if individual PCB, DDx and PAH compounds or groups are condensed into three comprehensive groups: total PCBs, total DDx, and total PAHs. Doing so reduces the number of contaminants with  $HQ \geq 1.0$  posing potentially unacceptable risks to 66.

- Risks to benthic invertebrates are clustered in 17 benthic AOCs.
- Sediment and TZW samples with the highest HQs for many contaminants also tend to be clustered in areas with the greatest benthic invertebrate toxicity.
- The COPCs in sediment that are most commonly spatially associated with locations of potentially unacceptable risk to the benthic community or populations are PAHs and DDx compounds.
- Not all COPCs posing potentially unacceptable risk have equal ecological significance. The most ecologically significant COPCs (i.e., contaminants of primary ecological significance) are PCBs, PAHs, dioxins and furans (as TEQ), and DDT and its metabolites.
- The list of ecologically significant COPCs is not intended to suggest that other contaminants in the Study Area do not also present potentially unacceptable risk.
- The contaminants identified as posing potentially unacceptable risk in the largest numbers of LOEs are (in decreasing frequency of occurrence) total PCBs, copper, total DDx, lead, tributyltin (TBT), zinc, total toxic equivalent (TEQ), PCB TEQ, benzo(a)pyrene, cadmium, 4,4'-DDT, dioxin/furan TEQ, bis(2-ethylhexyl) phthalate, naphthalene, and benzo(a)anthracene. The remaining 78 contaminants posing potentially unacceptable risk were identified as posing potentially unacceptable risk by three or fewer LOEs.
- Of the three groups of contaminants (i.e., total PAHs, total PCBs, total DDx) with the greatest areal extent of  $HQs \geq 1.0$  in the Study Area, PAH and DDx risks are

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and residual-range hydrocarbons that had concentrations that exceeded only the total petroleum hydrocarbons [TPH] SQGs) are not included in this count.

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largely limited to benthic invertebrates and other sediment-associated receptors. PCBs tend to pose their largest ecological risks to mammals and birds.

- The combined toxicity of dioxins/furans and dioxin-like PCBs, expressed as total TEQ, poses the potential risk of reduced reproductive success in mink, river otter, spotted sandpiper, bald eagle, and osprey. The PCB TEQ fraction of the total TEQ is responsible for the majority of total TEQ exposure, but the total dioxin/furan TEQ fraction also exceeds its TRV in some locations of the Study Area.

### **1.3 FS DATABASE DESCRIPTION**

As discussed in detail in the RI, environmental data have been collected within the Portland Harbor Site during numerous LWG sampling events and from other historical and concurrent studies and constitute the Portland Harbor Site Characterization and Risk Assessment (SCRA) database. The data lockdown date for the RI database was July 19, 2010. Additional data were added to the SCRA database through February 4, 2011, and used for the draft FS database. For the revised FS database (2014 FS database), EPA added surface and subsurface sediment data collected at the Gasco/Siltronic and Arkema early action sites through April 2011. Newer data from the RM 11E RI/FS activities are not included in the 2014 FS database. Data for all other media in the 2014 FS database are the same as those in the draft FS database. Tissue data are not included in either FS databases.

For the RI and FS, a date of May 1, 1997, was used to define the initiation of the sediment dataset to follow the last major flood of the Willamette River in the winter of 1996. Data evaluation, selection, totaling, and other rules and procedures for the FS databases are described in more detail in Appendix A. The RI database or the draft FS database may be used for some depictions or evaluations in this FS, and these instances are noted in the text when they occur. For example, the discussion in Section 1.2.3 and the associated tables (Table 1.2-1 and 1.2-2) and figures (Figures 1.2-5 through 1.2-17) are taken from the RI and use the RI database. Unless otherwise noted, the 2014 FS database was used in revised FS depictions and evaluations.

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